heart's action in carp, after being fully exposed by opening into the pericardium without any injury being done to the brain or spinal marrow, Mr. Clift next passed a hot wire from the tail to the occiput of a carp of the same size, so as to destroy its spinal marrow; and he found that the action of the heart was quickened for two or three beats, but then resumed the same rate of pulsation as before, although the voluntary muscles had lost their power and did not contract when a stimulus was applied to them.

After several repetitions of this experiment, with various modifications in the mode of conducting it, the author arrives at the following results:—

1st. That the muscles of the body of a carp can be thrown into powerful action four hours after the brain and heart are removed.

2dly. That those muscles lose all power as soon as the spinal marrow is destroyed.

3rdly. That by exposure of the heart to water in which the fish is allowed to swim, the action of the heart ceases sooner than in air.

4thly. That whether the heart is exposed or not, its action continues long after the brain and spinal marrow are destroyed; and still longer when the brain is removed without previous injury to its substance.

5thly. That the action of the heart is in general accelerated for a few beats by injuries to the brain or spinal marrow; but that destroying the spinal marrow after the brain has been separated renders the action of the heart slower for a few beats.

Some Experiments and Observations on the Colours used in Painting by the Ancients. *By Sir* Humphry Davy, *LL.D. F.R.S.* Read February 23, 1815. [*Phil. Trans.* 1815, *p.* 97.]

Beside the use which may be made of what remains of ancient paintings as models for imitation, the author has endeavoured to reap the further advantage of making us acquainted with the nature and chemical composition of their colours; for though the works of Dioscorides, Vitruvius, and Pliny contain descriptions of many substances used by the ancients as pigments, it is only by experiment that the subjects of which they speak can be identified.

The author's experiments have been made upon colours found in the baths of Titus, in the ruins called the baths of Livia, and other ruins of ancient Rome, and in the ruins of Pompeii. Some of these colours had been discovered in vases beneath the ruins of the palace of Titus, and were found to be the same as those used in various fresco paintings of the palace. In one large vase, discovered about two years since, there were found, among other colours, three different kinds of red, one approaching to orange, another dull red, and a third purplish red. The first was minium, the second and third proved to be both ochres of different tints. Another red found in various fresco paintings differed from those found in the vase, and proved to be vermilion. This substance, called by the Greeks κιννάβαρι, was known

by the name of minium to the Romans, who called our modern minium by the name of cerussa usta, in consequence of the mode of making it; which, on the authority of Pliny, is said to have been suggested by the accidental effects of a fire at the Piræeus at Athens, by which ceruse was found converted into minium.

From the description which Pliny gives of an inferior sort of vermilion, formed by calcining certain stones found in veins of lead, the author is of opinion, that the mineral thus treated must have been a natural carbonate of lead, which becomes red when burned.

Among the yellows examined by Sir Humphry Davy, were ochres of various tints, from being mixed with different quantities of chalk, and the yellow oxide of lead or massicot.

But though we have the evidence of Vitruvius that orpiment was known to the ancients, and of Pliny that a substance nearly allied to orpiment, termed Sandarach, was used by the Romans, the author has not been able to detect either of these sulphurets of arsenic in any of the ancient fresco paintings.

Among some rubbish collected in one of the chambers of the baths of Titus were several large lumps of a deep blue frit, which, upon being analysed, were found to consist of soda, silica, and oxide of copper. Upon examination of the different tints of blue observable in the paintings of the baths, as well as several blues in fragments of fresco painting from the ruins near the monument of Caius Cestius, and from excavations made at Pompeii, it appeared that they all consisted of the same blue frit, more or less diluted by admixture with carbonate of lime. There appears to the author every reason to believe this to be the colour described by Theophrastus, as discovered by an Egyptian king, and anciently manufactured at Alexandria. Vitruvius also speaks of the same colour under the name of cæruleum, made in his time at Puzzuoli, by heating together sand, flores nitri or natron, and filings of copper.

Though Pliny and Vitruvius speak of Indian blue, which appears to have been indigo, the author has not been able to discover any remains of it at this time; nor indeed of any other blue, excepting the frit before mentioned among the opake blues used by painters. But it is by no means uncommon to find among the ruins fragments of transparent blue glass, which are tinged with cobalt; and it would appear, from a passage in Theophrastus, that the Greeks considered cobalt as a species of χαλκὸς, in consequence of its property of giving this blue colour.

Among the several shades of green observable in the baths of Livia, the baths of Titus, and elsewhere, the greater part are coloured by carbonate of copper; but one of them, which approached the olive, proved to be the common green earth of Verona. It seems not improbable that some of the greens which are now found in the state of carbonate of copper may have been originally laid on as acetates; for it appears from Theophrastus that the ancients were well acquainted with verdigris.

The only trace of any thing approaching to the ancient purple

prepared from shell-fish is in a broken vase in the baths of Titus, containing a substance which at the surface has become of a cream colour, but in the interior has a lustre approaching to that of carmine. The colouring matter of this substance was found to be combustible, constituting about one thirtieth part of its weight, the remainder being a compound of siliceous, aluminous, and calcareous earths. It may, therefore, be regarded as a lake; but it would be very difficult, if not impossible, at this distance of time, to determine whether it be of animal or vegetable origin. In either case its durability, even in the interior of the mass, is a very curious circumstance, although the part exposed to the air has suffered the changes to which such colours have been too often proved to be liable, and accordingly no traces of it remain in any of the ancient fresco paintings.

All the blacks observable in the baths of Titus or elsewhere accord with the descriptions given by ancient authors, who speak of them as carbonaceous substances, obtained either as common charcoal or as soots of woods or resins.

The browns are sometimes mere oxides of iron or ochres, and sometimes mixtures of the oxides of iron and manganese; and it appears that the Romans had some knowledge of the properties peculiar to the latter substance, as Sir Humphry Davy has analysed two specimens of ancient Roman purple glass, both of which were tinged with manganese.

Among the whites of the ancient paintings, the author was unable to discover any ceruse, although it is known to have been in common use on the authority of Theophrastus, Vitruvius, and Pliny. The whites found are in general carbonate of lime, or fine white clays.

The ground to which the colours are applied in the ancient fresco paintings, is precisely such as is described by Vitruvius, powdered marble cemented by lime, highly polished and beautifully white. With regard to the mode in which their colours were applied, Vitruvius and Pliny agree as to the employment of wax in encaustic painting, which was subsequently liquefied by heat so as to give a varnish to the painting. But the author has not in any instance been able to detect the presence of wax, nor yet of any animal or vegetable gluten, in any of the fresco paintings, or even in the pot of colours found at Pompeii.

From the facts above stated, it appears that the Greek and Roman painters had the advantage over the great Italian masters, since the revival of civilization, in two of their colours, the Tyrian purple and the Egyptian azure, although the latter may easily and cheaply be imitated; for if a mixture of about fifteen parts of soda, twenty parts of powdered flint, and three parts of copper filings, be strongly heated together for about two hours, a frit is produced extremely similar in appearance and degree of fusibility to the ancient blue frit.